Persistent luminescence in the $M_2Si_5N_8:Eu^{2+},RE^{3+}$ family (M = Ca,Sr,Ba)

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Persistent phosphors are luminescent materials that continue emitting light for hours after being excited. The best known of these are $SrAl_2O_4:Eu^{2+},Dy^{3+}$ (green) [1] and $Sr_2MgSi_2O_7:Eu^{2+},Dy^{3+}$ (blue) [2]. Since their development, only relatively few other efficient persistent phosphors have been reported. Almost all of these are based on aluminates and silicates as host materials, doped with Eu^{2+} as luminescent centres, and codoped with trivalent rare earth (RE) ions to enhance the persistence. The persistent luminescence is believed to be caused by charge carrier traps inside the bandgap of the host material. However, the details of this mechanism remain unresolved [3].

The lack of efficient persistent phosphors is especially striking when looking at materials that emit light in the orange-to-red part of the visible spectrum. This is unfortunate, since such phosphors are ideal for use in safety signage. The reason for this scarcity is twofold. Firstly, at low light levels (below 1 cd/m², the mesopic and scotopic regime) the human eye sensitivity shifts to shorter wavelengths, making it more difficult to see orange and red light. Secondly, in oxides, it is difficult to achieve orange or red Eu^{2+}-based emission.

In order to explore new possible persistent phosphors, it is interesting to look at alternative host materials, other than the aluminates or silicates. In recent years, nitrides have drawn attention as promising hosts for conversion phosphors in LEDs, due to their physical and chemical stability. Earlier, we described orange persistent luminescence in $Ca_2Si_5N_8:Eu^{2+},RE^{3+}$, and showed that codoping with Tm yielded the brightest and longest afterglow [4]. We have extended this research to other members of the nitrido-silicate family, namely $Sr_2Si_5N_8$ (orange/red) and $Ba_2Si_5N_8$ (yellow/orange). We investigated their photoluminescent (emission, excitation) and persistent luminescent properties.

Upon codoping with the right rare earth codopants, all of the $M_2Si_5N_8:Eu^{2+}$ powders show a visible afterglow. For M = Ca this afterglow is the brightest, while for M = Sr it is barely visible. The materials can easily be charged with UV light. The charging efficiency with visible light, useful for indoor application, strongly depends on M (and is best for M = Ca). We have studied the influence of the (co)dopants, preparation conditions and starting materials. Thermo-luminescence measurements were performed to investigate the depths of the charge carrier traps.

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